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SYSTEM/PROJECT/PRODUCT: VMS

GENERAL HANDBOOK FOR

FLIP DOT VMS

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SAFETY WARNING

In the interests of Health and Safety, when using or servicing this equipment, the following instructions must be noted and adhered to :-

i) Only skilled or instructed personnel with relevant technical knowledge and experience, who are also familiar with the safety procedures required when dealing with modern electrical / electronic equipment are to be allowed to use and / or work on the equipment. All work shall be performed in accordance with the Electricity at Work Regulations 1989.

ii) Such personnel must take heed of all relevant notes, cautions and warnings in this handbook and any other document or handbook associated with the Variable Message Sign.

iii) The equipment must be correctly connected to the incoming mains supply.

iv) The equipment must be disconnected / isolated from any incoming power supply before removing any protective covers, or working on any part from which protective covers have been removed.

v) The VMS Processor uses a Lithium Battery for memory back-up. Siemens Plessey Code of Practice 526 must be adhered to for handling the VMS Processor PCB.

v) The VMS uses Sealed Lead Acid Batteries. Care must be taken in handling of these to prevent a short circuit condition occurring on any of the Lead Acid Cells.

PREFACE

It is intended that this preface should guide the reader as to the use of this handbook, thus assisting the reader in selecting the best section to read in order to obtain the information required.

Section 1

Introduction:- An introduction to both the handbook and the VMS system.

Section 2

General Description:- This gives an introduction to the VMS system.

Section 3

System Hardware :- A basic description of the hardware used in VMS.

Section 4

System Facilities :- A complete list of the facilities which can be provided by the VMS.

Appendix A

Custom Facilities :- A list of the custom facilities provided for the Department of Transport (UK)

CONTENTS

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to describe to the reader the Variable Message Sign.

1.2 SCOPE

This document is intended to introduce the reader to the Variable Message Sign manufactured by Siemens Plessey Controls Ltd. It covers the design hardware of the sign and the facilities which can be offered by the Siemens VMS.

Any custom facilities of the Siemens VMS system are included as Appendices of this document.

1.3 RELATED DOCUMENTS

VMS Installation, Commissioning and Maintenance Handbook

667/HE/24612/000

1.4 DEFINITIONS

SPCL	Siemens Plessey Controls Ltd
DoT	Department of Transport
VMS	Variable Message Sign
EMS	Enhanced Message Sign
EMI	Enhanced Matrix Indicator
CO	Central Office
LAN	Local Area Network
NMCS2	National Motorway Communications System Mark 2 (UK)
RS485	EIA Differential Data Communications Interface
RS232	EIA Data Communications Interface
EMC	Electromagnetic Compatibility
Pixel	One "dot" element in a 7 x 5 matrix display

1.5 ISSUE HISTORY

01.00A	First Draft for Review

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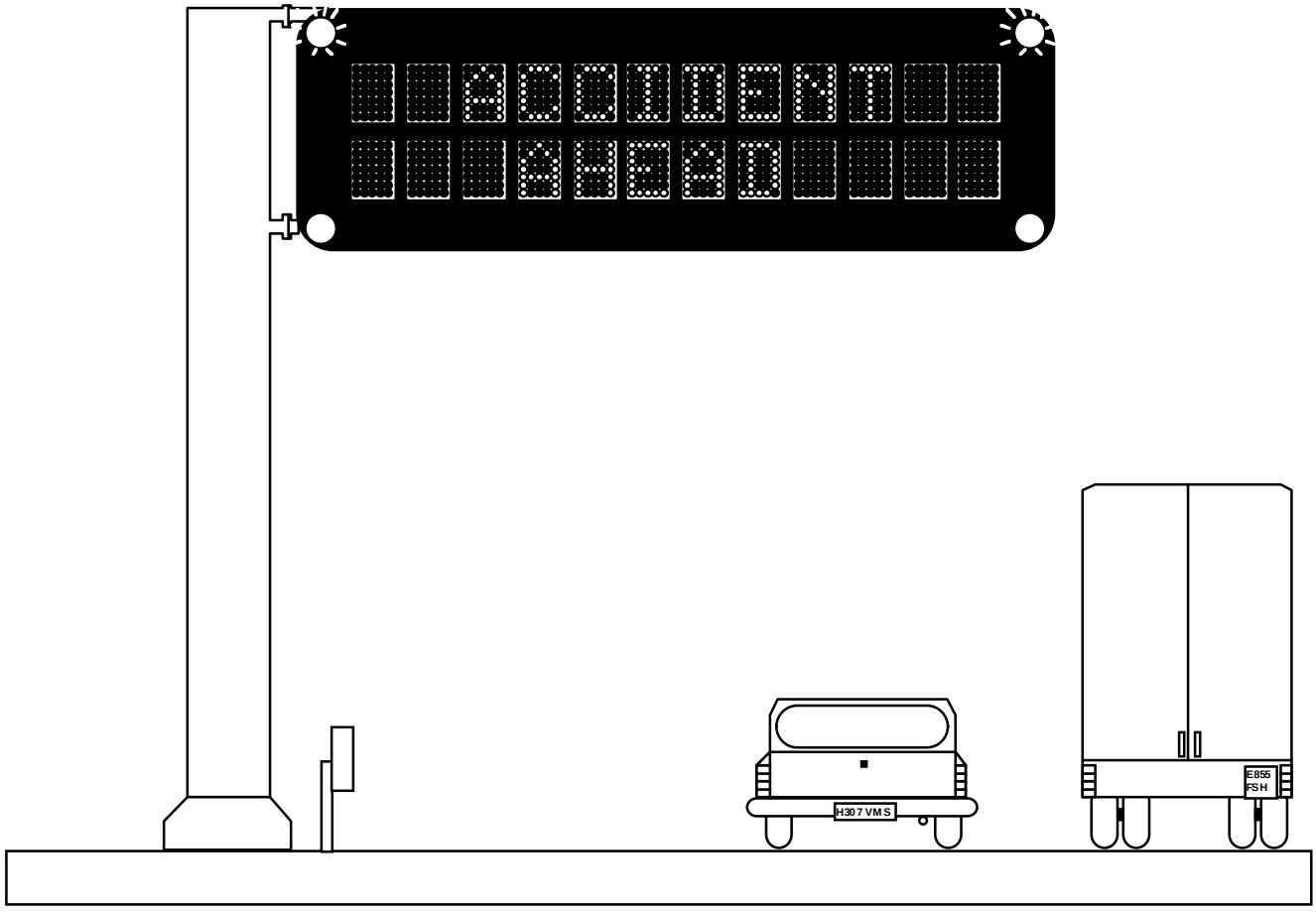
2 GENERAL DESCRIPTION

The Variable Message Sign system is used to display textual and graphical messages.

The signs use "Flip - Disc" + LED technology to display information on a dot matrix display area. This display area can be arranged as individual 7x5 dot matrix characters or as a continuous matrix of pixels.

A primary application of Variable Message Signs is to display information about traffic and weather conditions to drivers on the motorway.



Where the VMS is used to display information to drivers on the motorway, the display area is arranged in one of two formats. An **EMS** is used to display textual messages and an **EMI** is used to display symbols.

The **EMS** is made up from rows of characters, a standard being two rows of twelve characters.

The **EMI** is made up from a continuous matrix, a standard being 14 x 20 pixels in size.

The Variable Message Sign has a sophisticated electronics module which performs a control and monitoring function on the VMS. This is continually checking the sign for incorrect displays or faults.

In the event of an error being discovered, the electronics initiates fault recovery procedures to ensure a known state exists on the message display.

The hardware design of the VMS is described in detail in Section 3 of this Handbook.

The VMS system allows for control from several different sources, including a motorway control network (such as the UK NMCS2 system), a stand alone local controller or remote control via a modem and telephone connection.

The VMS design allows many different requirements to be catered for. Customisation of the sign is possible in all areas during the manufacturing process. A detailed list of the facilities offered by the Variable Message Sign is included in Section 4 of this Handbook.

3 SYSTEM HARDWARE

3.1 GENERAL

The aim of this section of the handbook is to introduce the reader to the constituent parts which are used in a Variable Message Sign. The three parts of this sections are detailed below:-

Display	The method used to display and draw attention to the message.
Control	The methods and procedures used to control and monitor the VMS.
Mechanical	The housing and mounting of the VMS.

3.2 DISPLAY TECHNOLOGY

A message is displayed on the VMS using an array of 7 x 5 dot matrix characters. These can be used to display textual or graphical symbols.

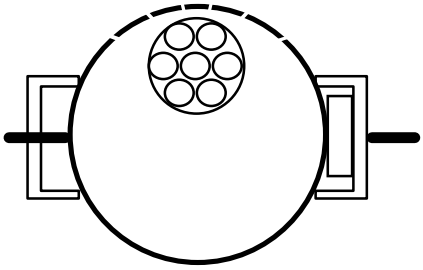
An **EMS** is made up from distinct characters to display textual messages.

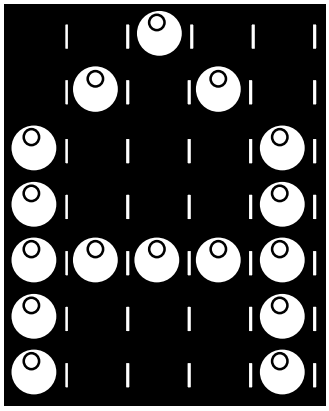
An **EMI** uses an array of 2 rows and four columns of characters which are mounted to form a continuous 20 x 14 pixel array.

The sign utilises a "flip-disc" with integral LED light sources manufactured by Ferranti-Packard in Canada. These "flip-disc" housings are mounted onto a printed circuit board in a 7 x 5 matrix to make up one character. They are capable of producing a full range of alphanumeric characters. See Fig 3.2a.

Discs can individually be selected on a 'ROW' and 'COLUMN' basis and are set *on* or *off* by interaction between permanent magnets and closely coupled electromagnetic coils.

FLIP - DISC





7 X 5 Character

Fig 3.2a - "Flip disc" + LED Character

Control signals set the direction of current pulses through the coils which establishes the direction of the magnetic field in the coils. The permanent magnet in the disc assembly is either attracted or repelled by the field produced in the coil. The 'flip disc' is magnetically latched in the position to which it was last turned until the coil field is reversed by another current pulse.

Power for the 'flip discs' is only required to change the information on the display. The inherent magnetic memory in the 'flip disc' magnetic circuit allows the display to be retained indefinitely without any need for power to the coils.

The character uses an integral array of LEDs mounted within the disc assembly itself. The array consists of both amber and yellow LEDs.

When the disc is active (i.e. with the 'reflective' face showing) the stored magnetic field within the disc coil also operates a reed contact which switches current through to the LEDs. The intensity of the LEDs is controlled by pulse width modulation of the supply current.

Each disc rotates freely on a pivot which provides trouble free operation of each pixel.

3.3 DISPLAY LANTERNS

The VMS has an option of using lanterns to draw attention to the current message being displayed. Where these are required, the coloured lanterns are mounted in the corners of the VMS. For an EMS, four amber lanterns are provided, one in each corner of the sign. For an EMI four amber lanterns are available with the option of four additional red lanterns.

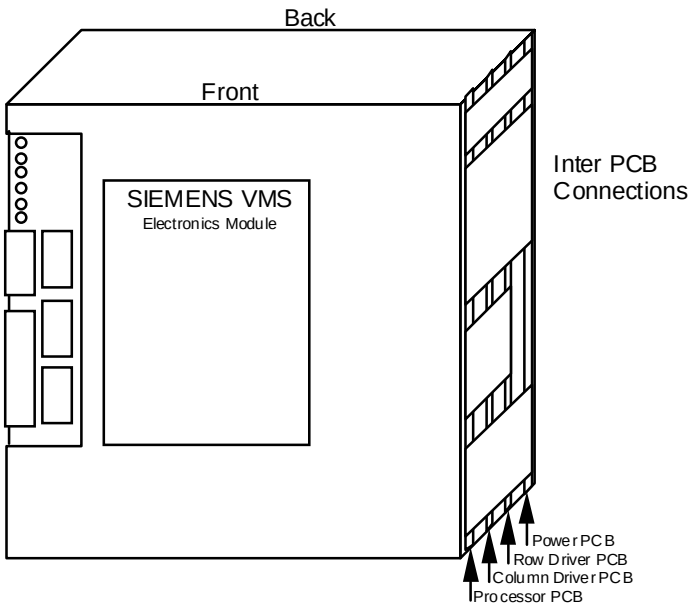
The lanterns use a fibre optic design with the lamps mounted internally to the enclosure. Fibres then transmit the light the front face of the sign where a 200mm lens is mounted. The lamps used are 12V halogen lamps with integral reflectors.

The fibre optic design allows the lamps to be changed easily without requiring access to the front face of the sign.

3.4 CONTROL

All the functions of the sign are controlled from the electronics rack which is mounted internally to the sign behind the display characters. The basic sign electronics rack contains four printed circuit boards, a mains distribution panel, power supplies and batteries. A standard EMS or EMI would require four PCBs which are briefly detailed below:-

- Processor (1 off)
- Row & Column Driver (2 off)
- Power Supply Distribution (1 off)



The printed circuit cards are all Double Extended Eurocard size, housed in a frame which is mounted behind the display modules, inside of the sign body. The arrangement of the PCB Module is shown in Fig 3.4a.

Fig 3.4a - Sign Control Electronics PCB Module

3.4.1 Processor PCB

The microcontroller used is selected from the Intel 80c188 range and its associated peripheral devices. The device operates using a 32MHz crystal with a processor clock speed of 16MHz.

The Processor PCB has 256k EPROM, 128k RAM, 4 Serial Channels, 6 16bit Timers, 108 I/O Lines, 8 Analogue Input Channels and a Real Time Clock.

The Analogue inputs have a range of 0 to 5V with 10-bit precision. they are used to monitor the current flowing in the LEDs and Lanterns, the ambient light sensors and the current flowing in the internal heaters.

The EPROM memory is split up into 128K for system programs, 128k for character and aspect sets and configuration.

3.4.2 Row / Column Driver PCB

This card provides the interface between the character modules, processor card and power supply distribution. It can be used as either a horizontal (ROW) switch or a vertical (COLUMN) switch which set up a *path* to intersect on a pixel within the character matrix. A current pulse, generated by the Power Supply Distribution card, is fed along this *path* to change the state of the flip - disc's magnetic core.

3.4.3 Power Distribution PCB

This card distributes all the power supplies required for the sign. It also provides monitors for these power supplies, the output of which is fed to the processor for fault logging.

This card also charges and monitors the Sign batteries to ensure they are at a full state of charge. Batteries are used to *blank* the Sign when a mains failure is detected.

The current pulse required to change the state of the 'flip - disc' magnetic core is generated on this board and is provided with an *anti-streaming* circuit to ensure correct operation. This current pulse is controlled by the processor and is switched by the Row & Column card.

Dimming of the LEDs and Lanterns is by pulse width modulation, under the control of the Processor. Current monitors are also used for operational status monitoring of the LEDs, Lanterns and the state of the 'flip - disc' cores. These are fed to the processor for fault logging.

3.5 MECHANICAL

The design of the sign enclosure employs a modular concept to accommodate different sizes and design of sign. The main points of mechanical design are detailed below:-

- Modular sign enclosure design
- Sliding doors for easy access to rear of enclosure
- Removal from rear of sign enclosure of all electronics
- Enclosure sealed to the requirements of IP56
- Vertical Adjustment of viewing angle for EMS
- Vertical / Horizontal Adjustment of viewing angle for EMI
- Coated polycarbonate front screen

A diagram showing the front and rear view of the basic sign enclosure is shown in Fig 3.5a and Fig 3.5b.

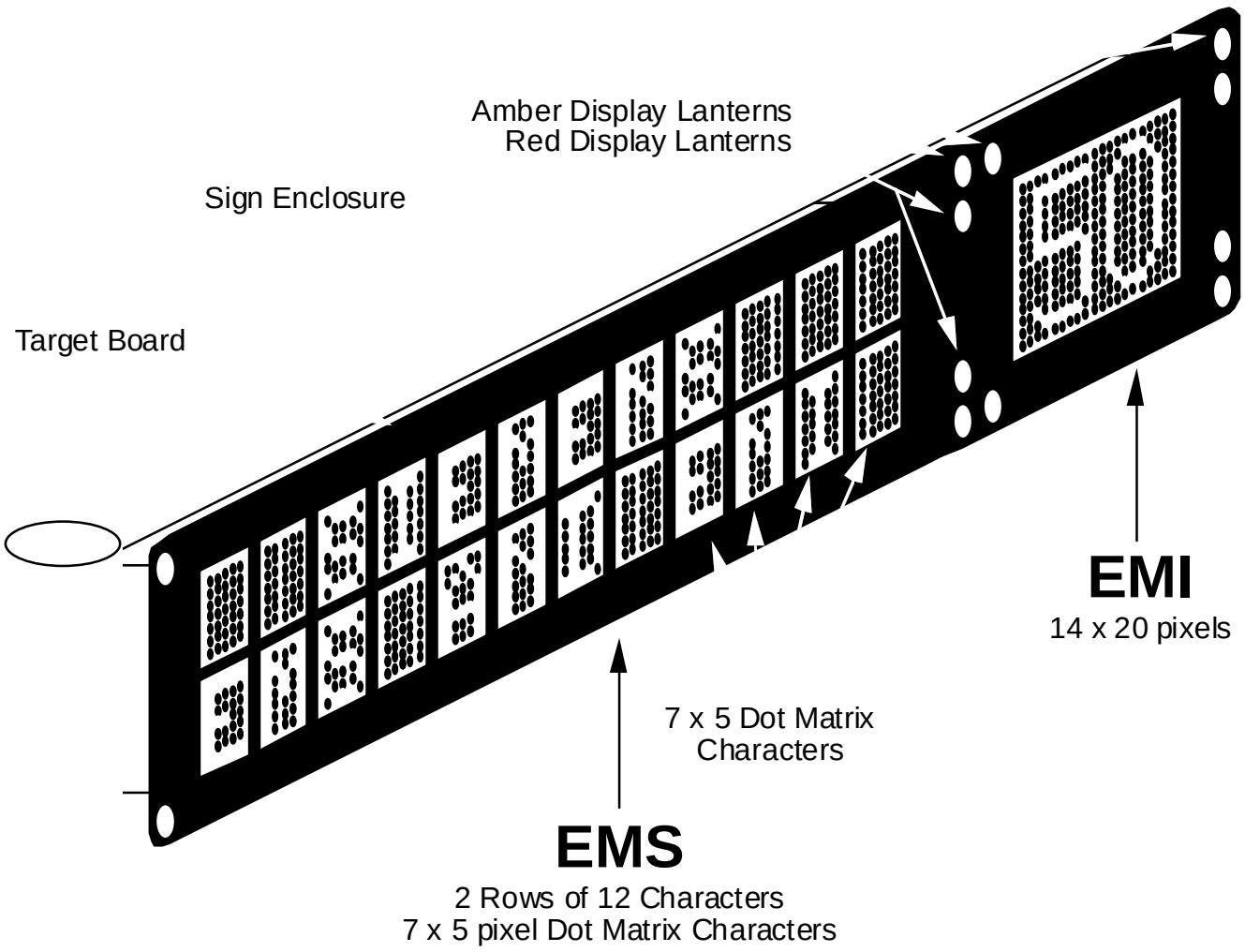


Fig 3.5a - Front View of VMS (EMS and EMI)

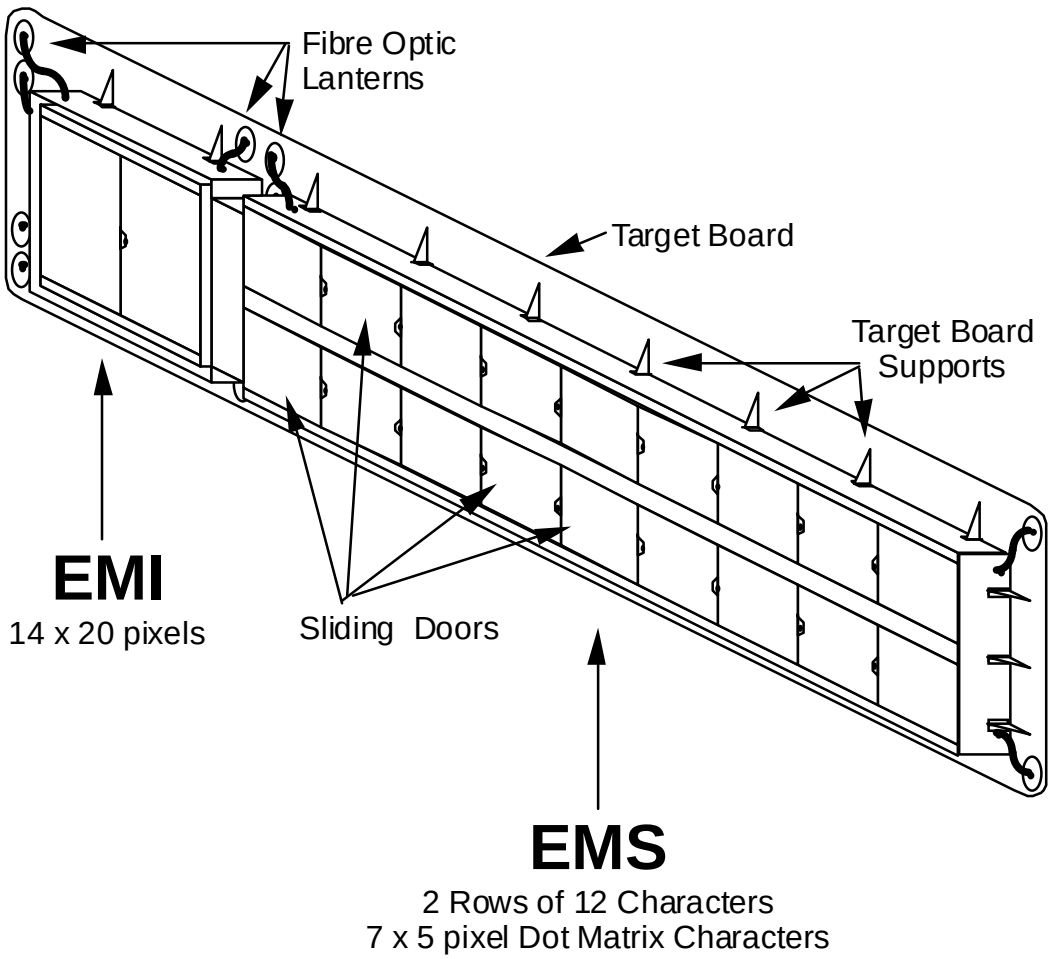


Fig 3.5b - Rear View of VMS (EMS and EMI)

4 SYSTEM FACILITIES

4.1 GENERAL

The VMS System offers a variety of different facilities to the user. These are listed below and detailed in the later parts of this section.

- Customisation in manufacture of all areas of the VMS
- Multiple Communications Interfaces
- Reliable "Flip Disc" + LED Display Technology
- Low Power Consumption when displaying a message
- Sign Size configurable in manufacture to many different applications
- Comprehensive Monitoring of Operation of Sign
- Comprehensive "Microsoft Windows" based Diagnostic Facility (with PC)
- Different Character Size's available in manufacture for all applications
- User Preset EPROM for Stored Messages, Fonts and Symbols
- Modular Mechanical Construction
- Commonality of parts between EMS and EMI parts of VMS
- Sliding Doors provide easy access to rear of sign for maintenance
- Mechanical Design allows easy replacement of any faulty modules in sign
- Optically tested to DoT Specification TR2136
- EMC Tested to DoT Specification TRG1068

- Environmentally Tested to DoT Specification TR2130B

4.2 COMMUNICATIONS

The VMS has four serial channels which are used for communication with other devices. The hardware interface for the four serial channels is detailed below:-

- Serial Channel 1 RS485 Isolated to the requirements of BS6301
- Serial Channel 2 RS232 with modem control lines
- Serial Channel 3 RS232 with RTS/CTS only
- Serial Channel 4 RS485 Non-Isolated

4.2.1 Serial Channel 1

- RS485 Differential Data Transmission
- Isolated to meet the requirements of BS6301
- Uses UK NMCS2 Protocol

4.2.2 Serial Channel 2

- RS232 Data Transmission Interface
- Complete with Modem Control Signals
- Uses UK NMCS2 Protocol

4.2.3 Serial Channel 3

- RS232 Data Transmission Interface
- Data Signals only

4.2.4 Serial Channel 4

- RS485 Differential Data Transmission Interface
- 2 or 4 wire Data Transmission

4.3 DIAGNOSTIC FACILITIES

4.3.1 Introduction

The VMS provides comprehensive diagnostic facilities in line with the extensive monitoring carried out on all aspects of the operation of the sign. This information is available to the user in two distinct ways:-

- Diagnostic LEDs on the PCBs in the electronics module
- A Comprehensive "Microsoft Windows" based Diagnostic Facility which runs on an IBM compatible PC.

4.3.2 Diagnostic LEDs

Diagnostic LEDs are provided on all the PCBs in the Electronics Module to indicate the presence of the correct power supply to each PCB.

In addition, the Processor PCB has Diagnostic LEDs to indicate the following:-

- Communications on Serial Channel 1
- Communications on Serial Channel 2
- Communications on Serial Channel 3
- Communications on Serial Channel 4
- Watchdog Status
- "Run" status - Indicates correct operation of software

4.3.2 Diagnostic Interface

The Diagnostic Interface uses a Serial Communication Channel on the Processor PCB to communicate with a PC.

After the PC is connected and powered up, it presents the maintenance engineer with a series of menus using the "Microsoft Windows" Operating system. These allow the engineer to interrogate the VMS on its current operational status and extract the fault log.

The fault log provides a record of any faults which are detected by the control electronics during normal operation of the sign. This fault log is stored in battery backed RAM and each entry in the fault log is time and date stamped by the Real Time Clock of the VMS.

During a power fail situation, the Real Time Clock is maintained by the same Lithium battery used for maintaining the fault log.

The facility is also available to set messages on the display for test purposes. This facility is password protected and requires acknowledgement of a warning before a display can be set.

4.4 DISPLAY

The design of the VMS is such that several options are available for configuring the display. As the sign is based upon 7 x 5 dot matrix type characters, virtually any message or graphic can be displayed. The size of the sign is variable up to set limits (See the Configuration Section) and is always implemented using the standard system hardware.

4.4.1 Display Modules

The sign display area will be made up of display cells, each composed of matrices of individual pixels arranged as a 7 x 5 block. Each display cell uses "Flip Disc" + LED technology to display the message or symbols (See Sec. 3.2). The 7 x 5 display cells are available in a variety of different sizes although the smaller sizes (100mm) high do not include an Integral LED source.

Fig 4.4.1a shows an example of a 420mm "Flip Disc" + LED Character.

The 420mm and 320mm display characters used in the VMS have been approved by B.S.I. to DoT Specification TR2136.

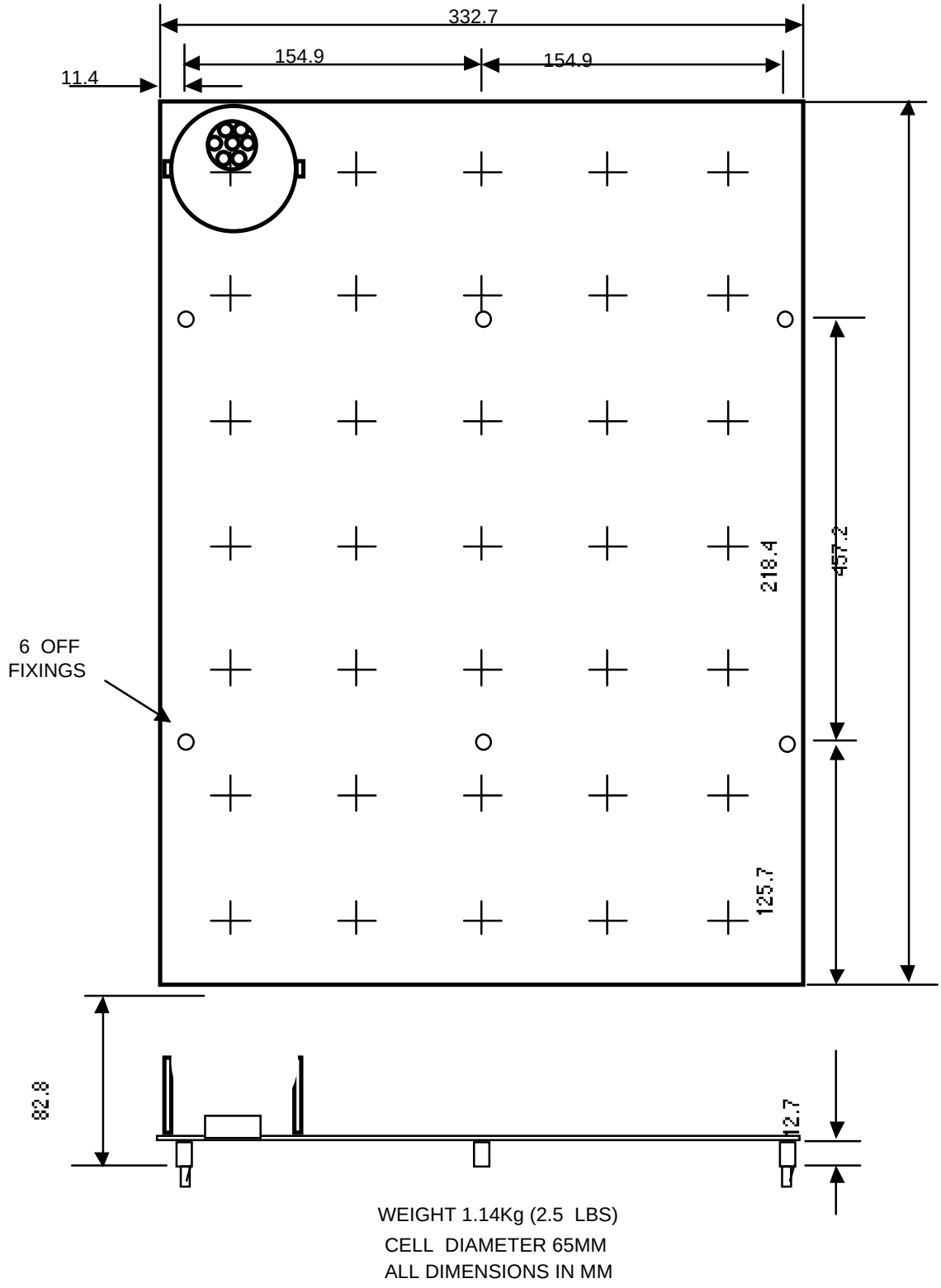


Fig 4.4.1a - 420mm "Flip disc" + LED Character

4.4.2 Sign Size

The size of the VMS is configurable in manufacture to the application. Each pixel of the display, whether it is a continuous matrix or text message type display, is addressed by selecting the corresponding row and column to set up a *path* to the pixel, Therefore the theoretical limit to the size of the sign is the number of rows and columns which the Processor PCB is able to address.

The Processor PCB is able to address 8 Row Driver and 8 Column Driver PCBs. The Row Driver PCB can drive four rows of 7 pixels and the Column Driver PCB can drive 6 columns of 5 pixels.

This gives a maximum sign size of 32 rows of 48 characters.

Alternatively the processor can control a continuous matrix (made up from 7 x 5) characters of 53, 760 pixels.

4.4.3 Display Lanterns

The option exists to fit Display Lanterns to a VMS (See Sec 3.2). These can be used to draw attention to the current message being displayed. These lanterns are fitted to the corners of a VMS as used in the UK motorway application.

The design of the lanterns incorporates fibre optic technology which allows the lamps to be mounted inside the enclosure and replace from the rear of the sign (See Sec. 3.2). This also allows the lanterns to be fitted to any reasonable location on the target board around the actual display area with the lamps being easily available for maintenance.

4.4.4 Anti-Condensation Heaters

The flip disc characters are mounted in the VMS behind a clear protective screen. To prevent condensation forming on the inside face of this screen, internal heating elements are used.

The heaters are tested as part of the background monitoring routine by the software for correct operation. The time interval between successive heater tests is preset and stored in the Configuration EPROM.

The operation of the heaters is controlled by a thermostat and a humidistat. If the threshold of either of these devices is reached the heaters are switched on to maintain the correct temperature and humidity of the sign.

An over-temperature device switches the heaters off if the internal temperature of the enclosure rises above a pre-set limit. At the same time, the processor PCB records an over temperature fault which is reported to the Central Office.

4.5 MONITORING

Extensive monitoring is carried out at all times on the VMS to ensure correct operation of all the functions of the sign. This is achieved in two ways:-

Sign Control Monitoring - Carried out during setting a display

Background Monitoring - Carried out at configurable intervals at all other times

The sign electronics monitors the operation of the sign to determine if any of the faults listed below have occurred.

- Lantern Fault
- Sign Power Supply Fault
- Lamp Failure
- Matrix Fault
- Internal Heater Fault
- Watchdog Reset Detected
- Internal Communications Fault
- Mains Failure Fault
- Over - Temperature Alarm
- Luminance Circuit Fault
- Disk Fault
- LED Fault

In the event of a fault occurring, an entry is made into the fault log which is time and date stamped using the Real Time Clock of the VMS.

The **Sign Control Monitoring** function is carried out when a display is set on the sign. It monitors the current flow through the disk coil and the LEDs. The current through the bulbs for the flashing lanterns is monitored to determine bulb failures and lantern conflicts. If a critical error is detected while setting the sign, the process is aborted and the message display cleared.

After the sign has been set, the background monitoring function continues to monitor the operation of the sign. This monitors the LED current to determine failures in the LED pixels. It continues to monitor the lantern current to determine the occurrence of lantern failures and conflicts. It also continues to monitor the overall sign operation, checking for any the faults listed above.

If no display is set, the sign performs background monitoring to check the overall operational status of the sign. This includes routine actuation's of the characters at configurable intervals to ensure they are operating correctly.

The **Background Monitoring** is carried out at nominal five second intervals. However this interval is adjustable, with the actual value stored in the configuration EPROM on the processor PCB.

4.6 CONFIGURATION OF VMS

The VMS has a configuration EPROM which is located on the processor PCB. This is used to store preset variables for each particular VMS installation. These variables are set during the manufacture of the VMS.

It has the facility to store the following :-

- 48 stored messages for an EMS (Maximum size of 6 rows by 40 columns of characters)
- 252 different characters for display on an EMS
- 50 Symbols of 14 x 20 pixels for display on an EMI
- 32 symbols of 42 x 20 pixels for display on a continuous matrix type EMS.

- The size of sign when configured as an EMS
- The size of sign when configured as an EMI
- The intensity levels which can be displayed on the sign, in response to the light sensors
- The sample period of the ambient light sensors on the sign
- The lantern flash rate for the Red and Amber lanterns
- The Pulse Width Modulation rate for the lanterns and LEDs on the sign.
- The availability of Main / Standby Lamps within the lantern assemblies
- The routine disk activation time (Time period between routine disk activation's of each character when the sign is not displaying a message)
- The time period between successive heater tests
- The availability of the battery test function carried out by background monitoring.

4.7 MECHANICAL FACILITIES

The design of the VMS uses a modular concept which is described in Sec. 3.5.

Each character is mounted on a backing plate which slots into guides internally to the sign. In the event of a failure occurring on a display character, this can easily be replaced by lifting out the single character from the rear of the sign. This enables individual characters to be replaced quickly and efficiently without disturbing any other part of the sign.

All the functional parts of the VMS are accessible from the rear of the enclosure which allows maintenance to be carried out without requiring the closure of all or part of the carriageway on the motorway below.

4.8 SPECIFICATION

4.8.1 Mains Voltage Range

The VMS will operate over the ranges:- 192 to 276 Vrms AC
86 to 132 Vrms AC

4.8.2 Mains Frequency Range

The VMS will operate over the frequency range : 47 to 63 Hz

4.8.3 Mains Current

When configured as detailed below, the VMS requires:-

2 x 12 EMS	3.0A at 240V
EMI	2.0A at 240V

Note:- These figures do not include current drawn from the maintenance socket.

These figures are for the worst case of a test display with lanterns and LEDs all on full brightness. The actual current drawn is much lower and will depend on the brightness of the lanterns / LEDs and the number of pixels which are active at any one time.

4.8.4 Optical Requirements

The sign meets the requirements of the DoT Specification TR2136 and European Specification TCC226 for optical performance, measured to the CIE 1931 Chromaticity Chart.

4.8.5 Environmental Requirements

The VMS meets the requirements of the DoT Specification TR2130B as detailed below:-

a) Dry Heat - Test to 60 Deg C

b) Cold - Test to -15 Deg C

c) Damp Heat

d) Water Penetration - equivalent to IP56

e) Bump (Packaged)

f) Vibration (Unpackaged)

g) Drop (Packaged)

All of these tests were carried out by an independent NAMAS approved test house.

4.8.6 EMC Requirements

The VMS meets the requirements of the relevant sections of DoT Specification TRG1068.

The EMC testing was carried out on the VMS by an independent NAMAS approved test house.

A APPENDIX A

A.1 DoT Custom Facilities

One application for the VMS is in motorway signalling, providing information to passing motorists about conditions ahead. In this instance, the VMS is controlled by the NMCS2 Control Network used on the motorway signals and emergency telephones.

In this application the sign itself is controlled by the sign driver which connects to the NMCS2 RS485 Control network. Fig. A.1a shows the arrangement of the sign driver and the sign (EMI + EMS type sign).

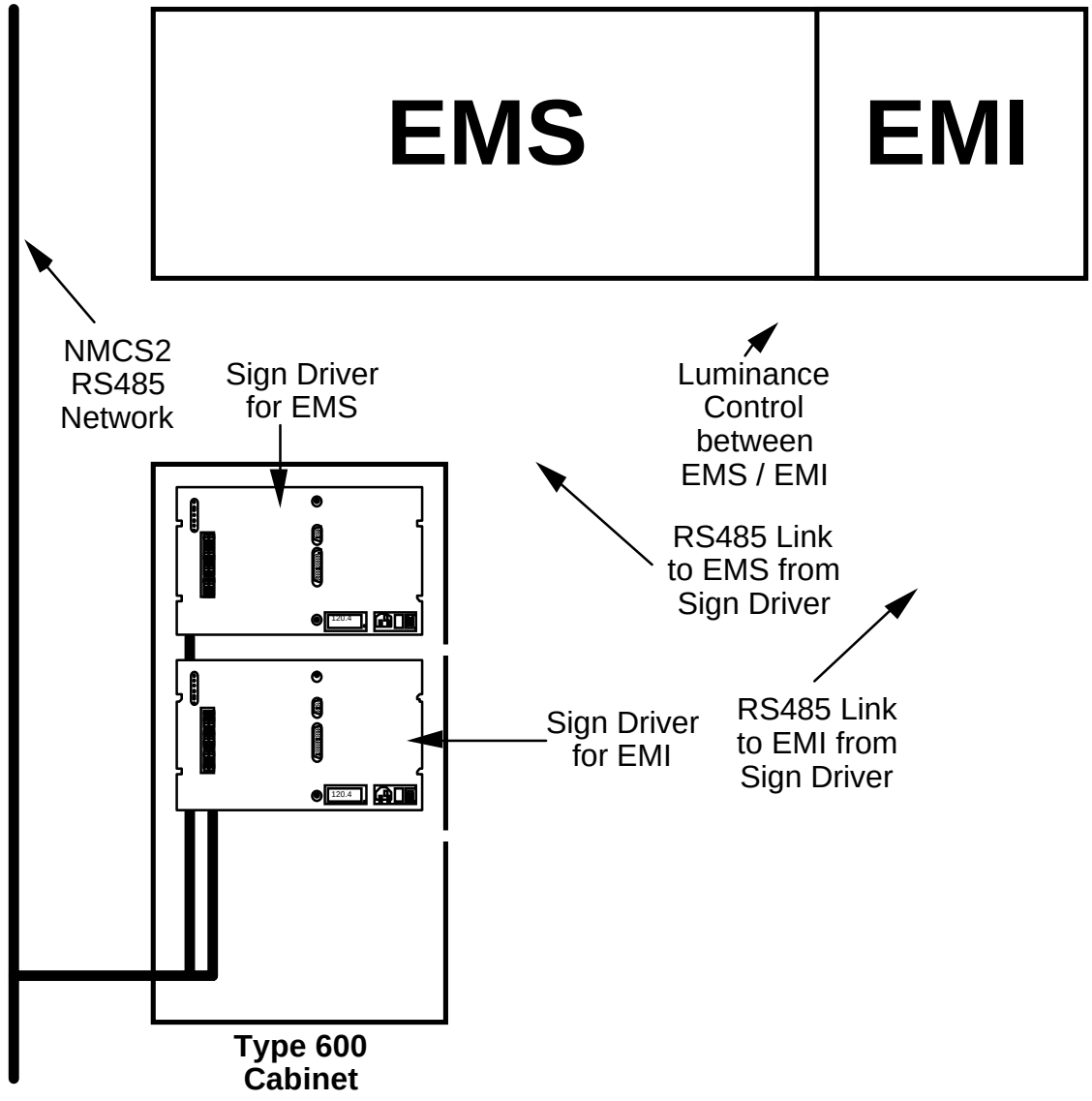


Fig A.1a - Arrangement of Sign and Sign Driver

The sign driver is mounted in a Type 600 cabinet at the side of the motorway and communicates with the sign mounted on the gantry. A separate sign driver is used for the EMS and the EMI. The sign driver provides the diagnostic and site address information for the sign in the Type 600 cabinet. Communication between the sign driver and the VMS is made using an RS485 serial communications link.

The sign driver is a 19" unit which mounts in a DoT Type 600 Cabinet. It uses the same processor PCB as the VMS itself. This offers the benefits of reduced spares required, as the same processor hardware is used for the VMS processor in an EMS or an EMI and in the sign driver. A diagram of the front of the sign driver is shown in Fig. A.1b.

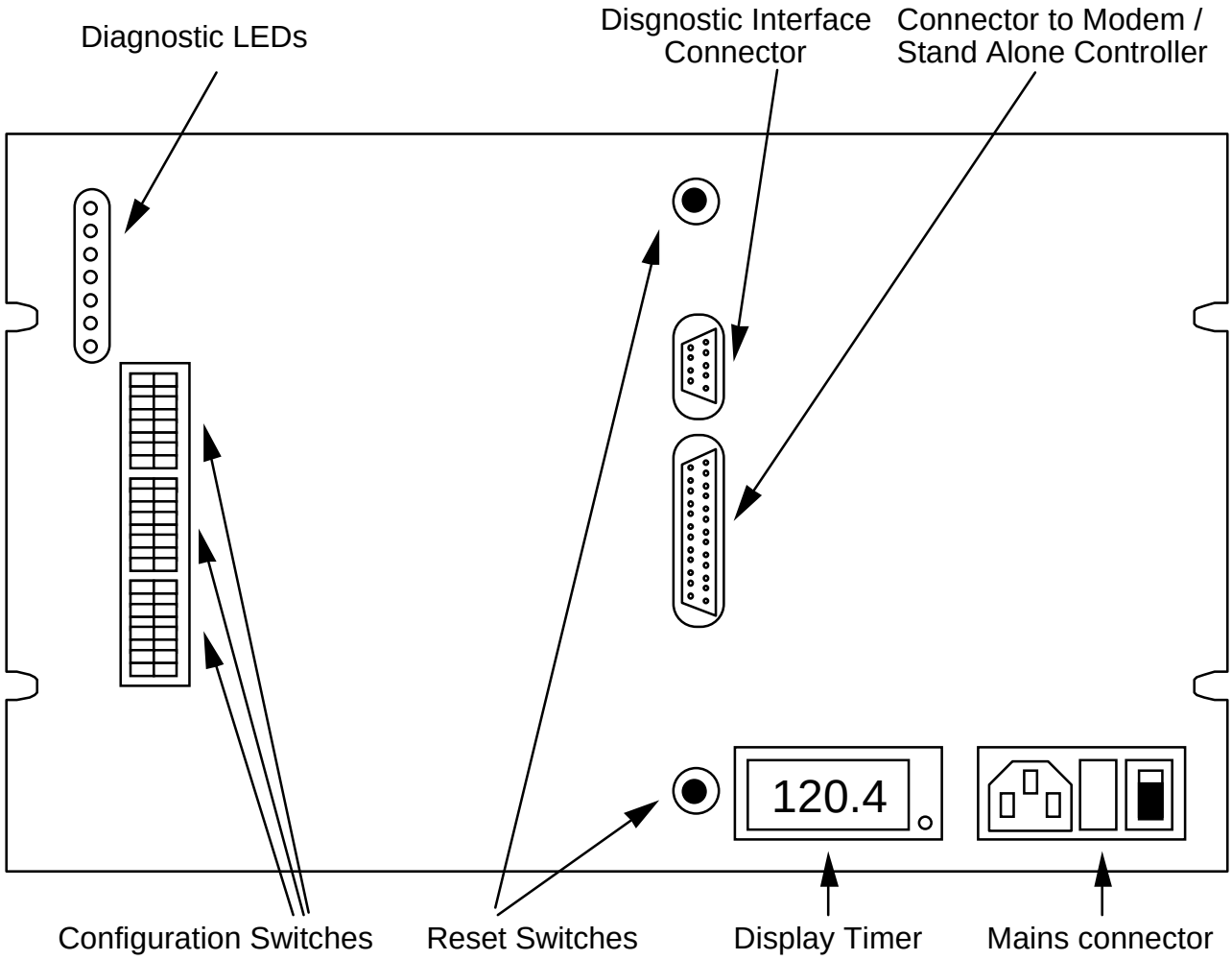


Fig A.1b - Front View of Sign Driver